# THE DEVELOPMENT OF YOUNG STANDS OF NATIVE SPRUCE AND FIR IN NEWFOUNDLAND

by
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ST. JOHN'S, NEWFOUNDLAND
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## INTRODUCTION

Considerable attention has been given in the Newfoundland Region research program to studies of the establishment of regeneration and of the growth and yield of merchantable crops. Such topics have been and will continue to be major and essential parts of the program. The emphasis on these topics has, however, resulted in a relative lack of information on the development of stands of native species between the time of regeneration establishment and attainment of merchantable size. Young crops at this early stage of development are now beginning to assume greater importance to forest research and management with the development of studies into treatments for controlling density and distribution to achieve optimum production.

Very few studies have been carried out specially to investigate the development of young stands of spruce and fir in Newfoundland. Data on this topic have, however, been collected in a number of studies which were designed, primarily, to test the effects of various site and stand treatments on regeneration success. As a result, sufficient data are now available to permit the preparation of this preliminary report on early stand development.

Some of the results contained in this report have already been published. However, the majority are presently only available as file material. It is the purpose of this report to bring these data together, to present them in a standard format so that comparisons are possible, and to detect developmental trends which require further investigation. The resulting information should be of direct application to growth and yield, stand development, and stand treatment studies, while also providing clear indication of those stages in young stand development where information is still lacking and thus where continued work is required.

The development of young stands of native softwood species (balsam fir, *Abies balsamea* (L.) Mill.; black spruce, *Picea mariana* (Mill.) BSP; white spruce, *Picea glauca* (Moench) Voss) following establishment will be reported in terms of number of stems per acre, percent stocking, height and height increment, and, in a limited number of cases, diameter growth, and mortality. Regeneration occurring naturally or resulting from any given treatment will be taken as the starting point from which further development of the young stands will be followed. The relative merits of various cultural treatments for obtaining successful regeneration will not be considered.

## METHODS

### Sources of Data

Data have been obtained from closed and active studies carried out in central and western Newfoundland from 1950 to the present. Projects concerned are listed below. With the exception of project NF-47, each of these studies has involved the remeasurement over a period of time of a number of permanent quadrats.

(1) Projects NF-10 and NF-45.

'Development of black spruce on plots artificially seeded in 1950, Cormack, Newfoundland'. Three seeding treatments were used (broadcast seeding on snow; broadcast seeding on turf; seedspots) on well drained loam on a 1949 burned cutover in western Newfoundland (Forest Region B28b: Rowe, 1959). Treatments were applied on 1/10 acre plots, replicated five times. Forty-eight milacre quadrats were established systematically in each plot.

Period of observation: 1951-1961. Factors measured: percent stocking, height and height increment, and diameter (1961 only). Data from Dickson (1955) and van Nostrand (1964a).

(2) Project NF-18.

'Experimental seeding - balsam fir'. Consists of four seeding treatments (broadcast on turf at high, medium, and low intensities, and seedspots) plus an unseeded control. Eight replicates, each consisting of 25 square milacre quadrats arranged in five rows (treatments) of five quadrats each, were located randomly over the experimental area which is on an exposed upper slope near Hampden, western Newfoundland (Forest Region B28b). The soil is well-drained having a high stone content and a sandy loam texture. The area was cut between 1950 and 1952 and burned in 1952.

Period of observation: 1953-1963. Factors measured: percent stocking, height and height increment. Data from Dickson (1957), and van Nostrand (1964b; 1965).

(3) Project NF-23.

'Southwest Gander black spruce seedbed study'. Involves strip cutting in dense black spruce stands of fire origin in central Newfoundland (Forest Region B28a), with alternate 100-foot-wide cut strips and 200-foot-wide uncut strips. Five plots were laid out across the full width of each of these cut strips. Each plot consisted of two adjacent rows of contiguous milacre quadrats. Soil is a well-drained podzol of a loam texture. Over most of the area the organic mantle is a mor humus varying from five to ten inches in depth.

Period of observation: 1956-1960. Factors measured: number of seedlings per acre, percent stocking, and mortality. Data from van Nostrand (1961; 1962).

(4) Project NF-41.

'Large scale cutting experiment number five'. An investigation into the effects on future stand development of cutting or leaving trees in the 4-inch diameter class during regular cutting operations in virgin forest at Stag Hill, western Newfoundland (Forest Region B28b). Pure balsam fir, pure black spruce, and mixed spruce-fir forest types on varied site conditions were sampled, using permanent transects and three-milacre sub-plots.

Period of observation: 1956-1961. Factors measured: number of stems, percent stocking, and height (1961 only). Data from van Nostrand and Nickerson (1965).

(5) Project NF-47.

'An investigation of the length of the regeneration period and of the yield potential of pulpwood cutovers in Newfoundland'. One-time observations of young stand development on cutovers on the Sandy Brook and Noel Paul's Brook areas of central Newfoundland (Forest Region B28a). Several site types and young stands of ages from 3 to 22 years were sampled systematically, using groups of four milacre quadrats. Total number of samples varied between types.

Factors measured: number of stems, percent stocking, height growth, and volume growth (18-22 year old stands only). Data from Ellis (1960).

(6) Project NF-72.

'Assessment of results of balsam woolly aphid control operations in Newfoundland'. Study carried out to determine the effects on future regeneration of leaving black and white spruce seed trees on four cutover areas in central and western Newfoundland (Forest Regions B28a and B28b). Groups of five milacre sample plots were laid out at 2½ chain intervals along lines 5 chains apart. Total number of samples varied between each of the four areas. Soils are predominantly freely-drained and of a sandy loam texture.

Period of observation: 1963-1968. Factors measured: Number of seedlings, percent stocking, height, and height increment. Data from Robinson (1969).

(7) Project NF-84.

'Aerial seeding of burned-over land using a mixture of black spruce and jack pine seed'. Carried out at North Pond experimental area, central Newfoundland (Forest Region B28a) on 1961 burn. Soil is predominantly freely-drained and of a sandy loam texture. The seeded area was sampled with 30 milacre quadrats, laid out along one line at 2-chain intervals.

Period of observation: 1965-1968. Factors measured: number of seedlings and percent stocking. Data from Richardson (pers. comm.)

(8) Project NF-86.

'Seedspotting a 1963 prescribed burn using three species of spruce' (including black spruce). Experimental areas are at Fishel's Brook, western Newfoundland (Forest Region B28b) where the soil is a well-drained, silty loam, and at Norris Arm, central Newfoundland (Forest Region B28a) on well-drained sandy loam soils. A total of 300 individual seedspots were sampled in each area.

Period of observation: 1963-1968. Factors measured: number of seedlings, percent stocking, height and height increment. Data from Richardson (pers. comm.).

(9) Project NF-98.

'Broadcast seeding a 1961 burn by cyclone seeder following ground scarification'. Carried out at North Pond experimental area using black spruce. Four seeding treatments were used and replicated four times. A total of 80 milacre quadrats were laid out systematically in each treatment.

Period of observation: 1965-1968. Factors measured: number of seedlings, percent stocking. Data from Richardson (pers. comm.).

Data Analysis

In most cases the data from these projects were available in a suitable form, from published or file reports. The only additional work necessary was their presentation in a standard tabular form and the preparation of graphs to illustrate the trends. For Project NF-72 additional calculations had to be made from the original tally sheets.

Number of stems per acre, percent stocking, and height are the only stand parameters that have been recorded on a sufficient number of occasions to permit analysis. Data on other parameters are presented where possible but are too few to permit any definite conclusions to be drawn.

Results are presented separately for fir and spruce. Separate figures for black spruce and white spruce were not recorded in Project NF-47, and therefore no separation of the two species is possible. Figures for total softwoods and for hardwoods are not available from most of the projects. Where available, such data have been included in the tables. However, they are too limited for inclusion in the diagrams or for the detection of any consistent trends.

Data for each parameter and each species have been further divided on the basis of the original site or stand treatment, in order to clarify the development trends. Treatments recognized are (i) direct seeding, (ii) retention of seed trees, and (iii) clear cutting. The latter group includes figures for spruce and fir on normal cutovers, and for fir only on areas where spruce seed trees have been left.

## RESULTS AND DISCUSSION

### Number of Stems per Acre

Data from five projects on the trends in number of stems per acre over the first ten years of stand development are listed in Table 1 (Appendix 1). Table 4 includes data on number of stems per acre for the first 20 years on cutovers in central Newfoundland. Cross references to the numbered trend lines in Figures 1-15 will also be found in Tables 1-4.

No single, overall trend is apparent from these data either for spruce or fir alone or for the total number of softwood stems. However, when the data are split on the basis of the original site or seeding treatment, indications of some consistent developmental trends become apparent.

Data for number of balsam fir stems per acre on cutovers show a regular pattern of development (Figure 1) which is considered representative of the typical course of development for all softwood species. Plots which initially contain very large numbers of balsam fir seedlings (over 50,000 per acre) show a very rapid decrease during the first five-year period (in particular during the first three years), with only a gradual decrease during the following fifteen years (Table 4). Where initial numbers of trees are lower (less then about 30,000 per acre), the decrease is less rapid, and for initial figures of less than 10,000 balsam fir stems per acre an increase during the first five-year period can be observed in most cases.

Black spruce and white spruce show a very irregular course of development on cutovers (Figure 2), with no discernible pattern being established. However, most of the data for spruce on cutovers are representative of only a small and relatively slow-growing part of the new crop. In most cases large numbers of faster-growing fir are also present, preventing the spruce from developing in the way it might be expected to do if it were alone. This condition is illustrated by all four forest types sampled in project NF-47 (Table 4) where spruce constitutes only about 1% of the total number of softwood stems.

The number of stems per acre in young spruce stands resulting from seed tree, strip cutting, or direct seeding treatments has increased during the period of observation in almost all cases (Figures 3 and 4). Initial numbers were below 4,000 per acre, and the increases are therefore in

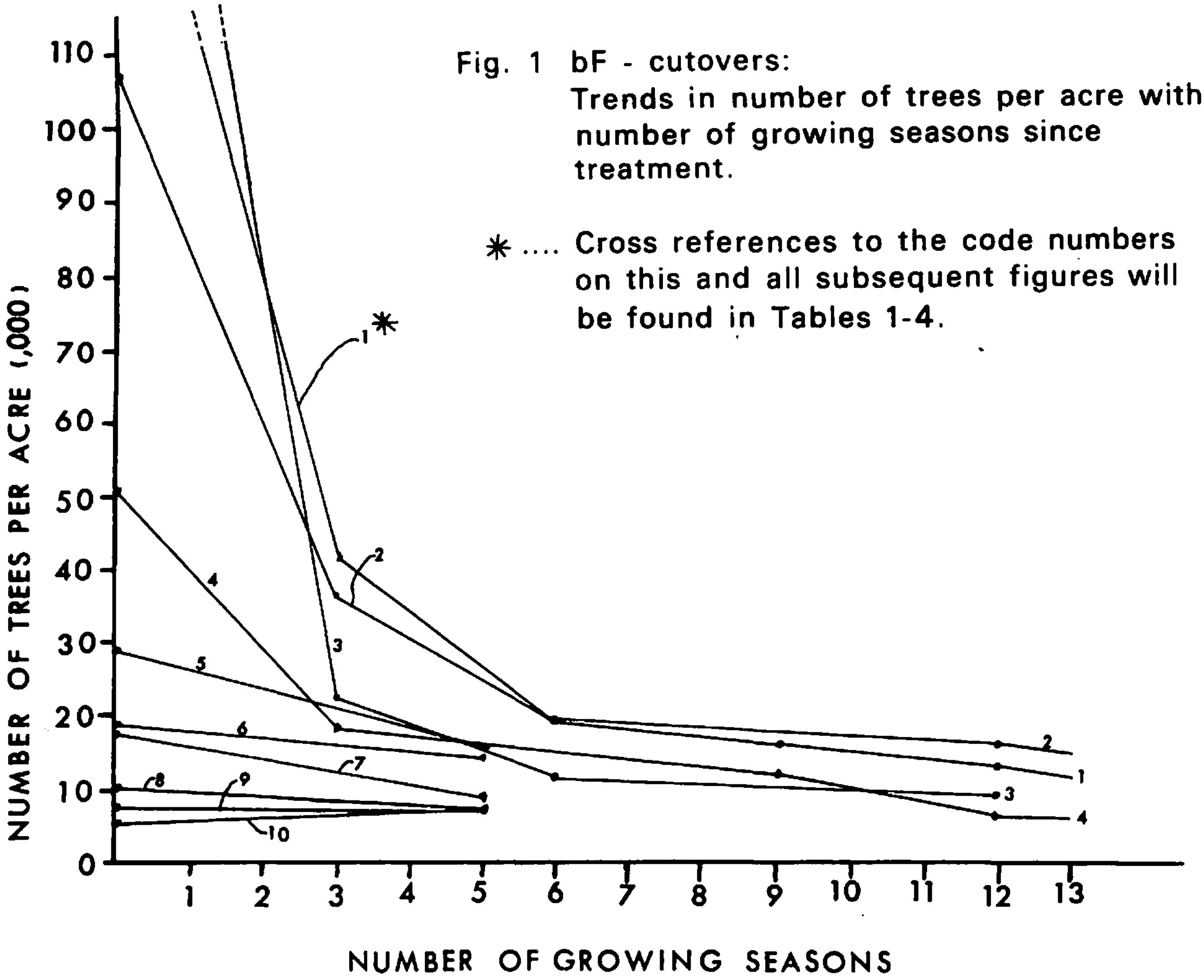



Fig. 1 bF - cutovers:
Trends in number of trees per acre with number of growing seasons since treatment.

* .... Cross references to the code numbers on this and all subsequent figures will be found in Tables 1-4.

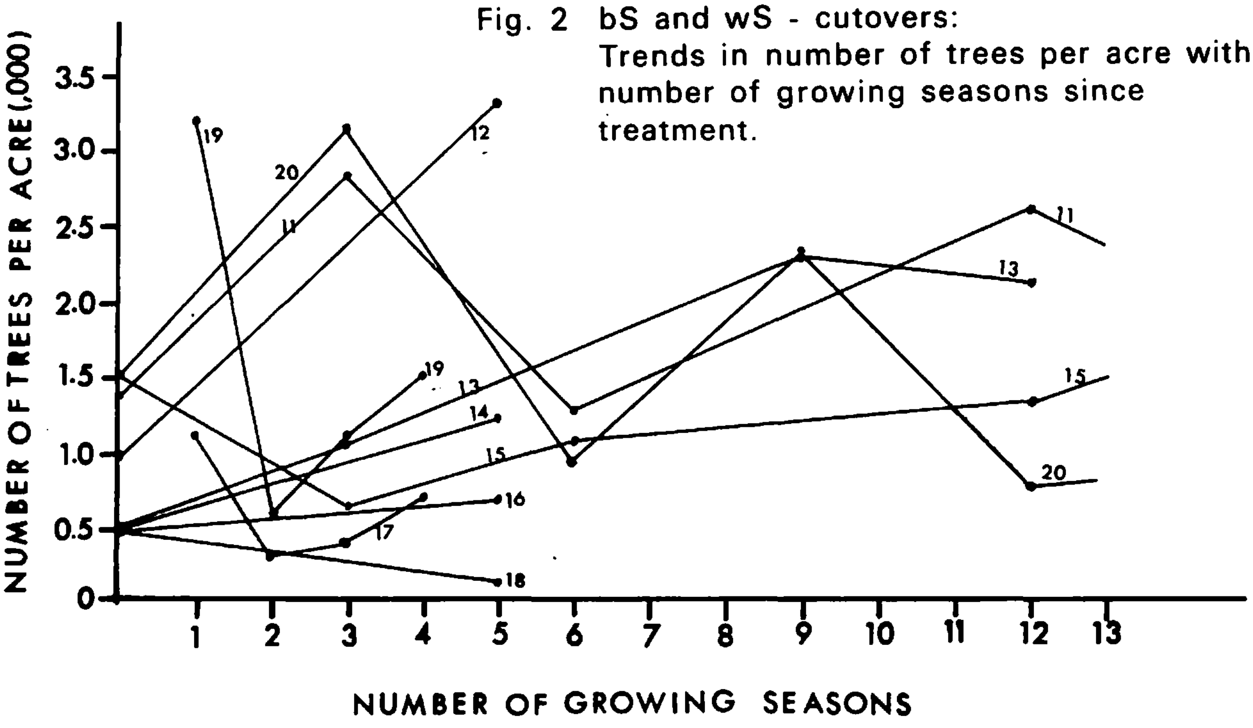



Fig. 2 bS and wS - cutovers:
Trends in number of trees per acre with number of growing seasons since treatment.

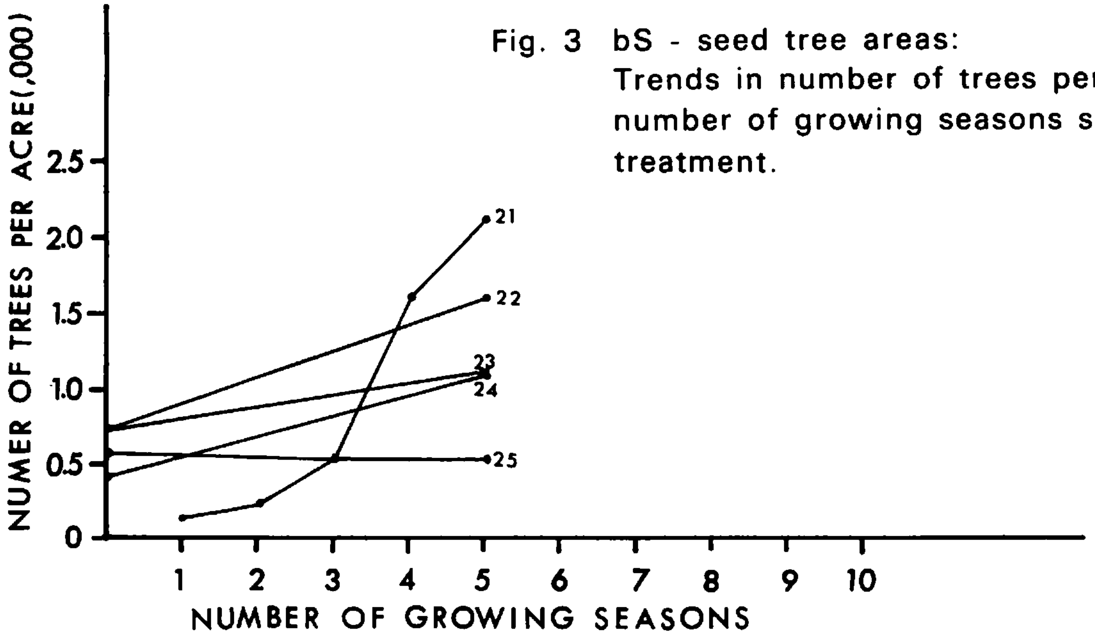



Fig. 3 bS - seed tree areas:
Trends in number of trees per acre with number of growing seasons since treatment.

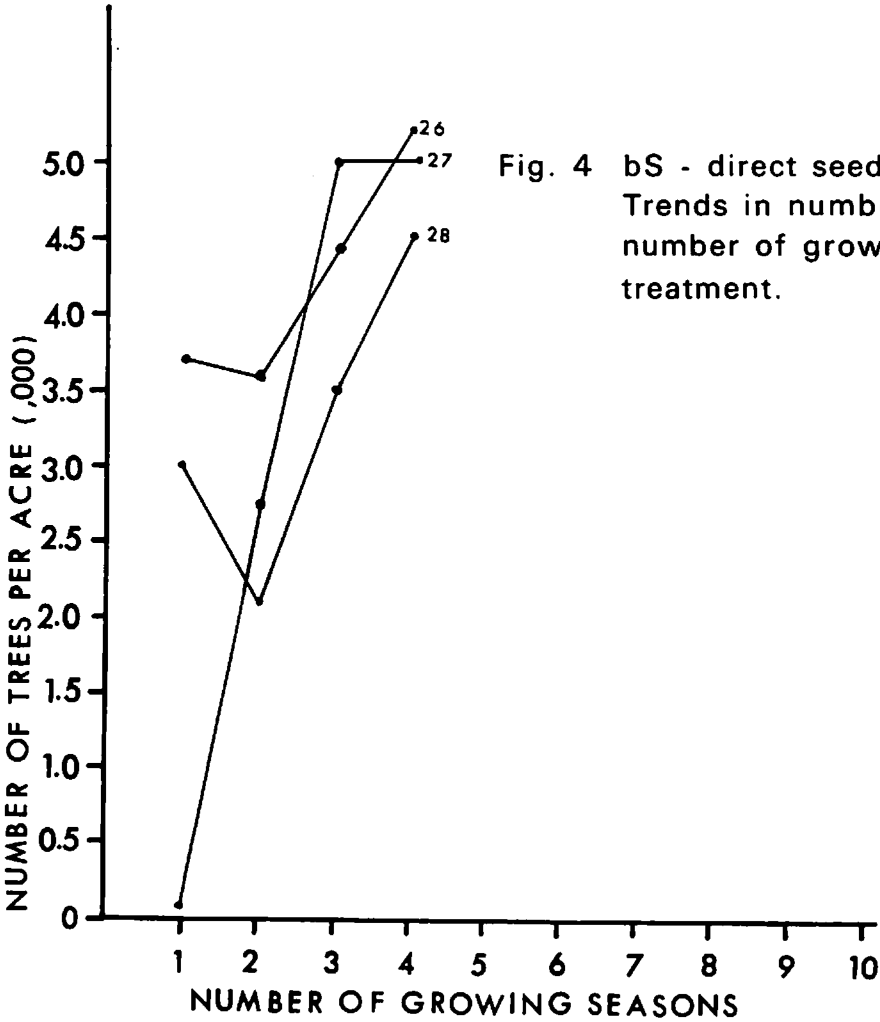



Fig. 4 bS - direct seeding:
Trends in number of trees per acre with number of growing seasons since treatment.

agreement with those observed on balsam fir cutovers where numbers were low (see Figure 1, trend lines 9 and 10).

There appears to be a tendency for the total number of softwood stems to develop a density of 5,000 to 10,000 stems per acre at 15 to 20 years, regardless of the number of seedlings or advance growth stems initially present. This is apparent for the balsam fir cutovers in Project NF-47 (Table 4), and similar tendencies can be observed in the four- to five-year-old crops measured in projects NF-72 and NF-98 (Table 1). This process must require suitable seedbed media, an adequate seed supply and the absence of any extreme competition from vegetation to permit the number of stems to increase in areas where initial numbers are low. Equally, there must be intense competition, probably aided by exposure effects, in the high density regeneration to cause reductions of the magnitude observed. Where seedling numbers appear likely to remain low, some deficiency of seed supply or seedbed conditions, or severe vegetative competition appear the most likely causes.

Percent Stocking

Table 2 (Appendix I) lists data on percent stocking from nine projects covering the first ten years of stand development. Twenty-year figures for cutovers in central Newfoundland are included in Table 4.

As in the case of number of stems per acre, there is no one trend which is followed by all data. Results for individual treatments are plotted in figures 5-9. These graphs show for both spruce and fir that where percent stocking was initially less than 50% there has in most cases been an increase during the period of observation. Above 50% both increases and decreases occur, although the overall trend during the twenty-year period of observation seems to indicate maintenance of the original figures. A detailed comparison of data from different projects is, however, not possible owing to the use of different regeneration sampling methods and intensities.

Percent stocking figures provide only a very insensitive measure of number of stems per acre present on the sample areas. The relationship between stocking and number of trees from the data used in this report is illustrated in Figure 10. Stocking figures between 85% and 100% can correspond to numbers of stems per acre between 5,000 and 180,000. Moreover, a very rapid change in number of stems per acre can take place while stocking figures remain more or less constant. Forest type 3 in project NF-47 provides a good example (Table 4). During the first three years after cutting the number of stems per acre declines from 152,800 to 42,200 (trend line 1, Figure 1) while stocking remains constant at 99% (trend line 29, Figure 5). The rapid decrease in number of stems in dense regeneration and the more or less constant percent stocking figures would therefore seem to be representations of the same basic trend. It is, however, impossible to detect this trend from the stocking figures alone, suggesting that smaller quadrats may be more efficient in heavily stocked areas. With lesser numbers of stems per acre the percent stocking values are much more sensitive to any change.

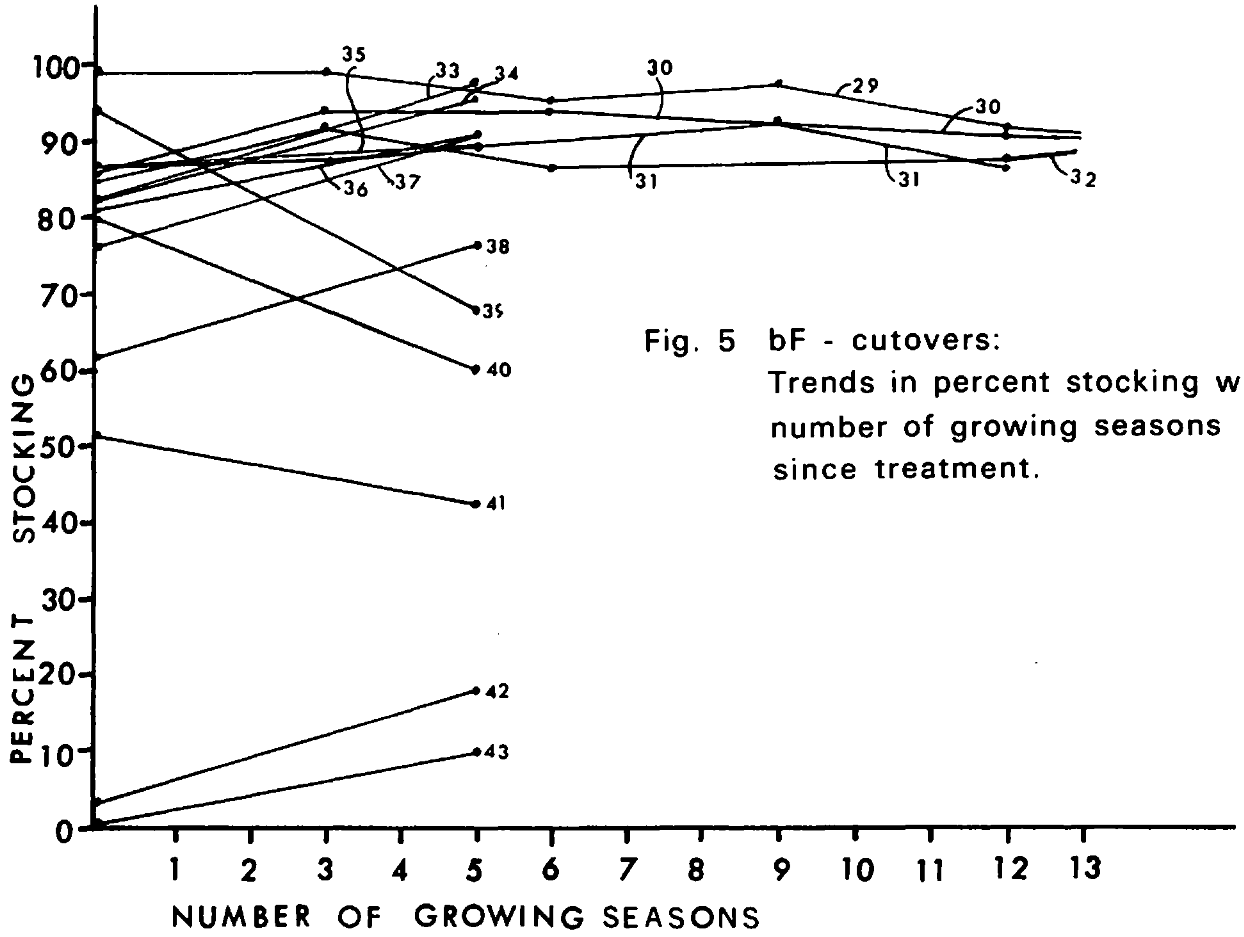



Fig. 5 bF - cutovers:
Trends in percent stocking with number of growing seasons since treatment.

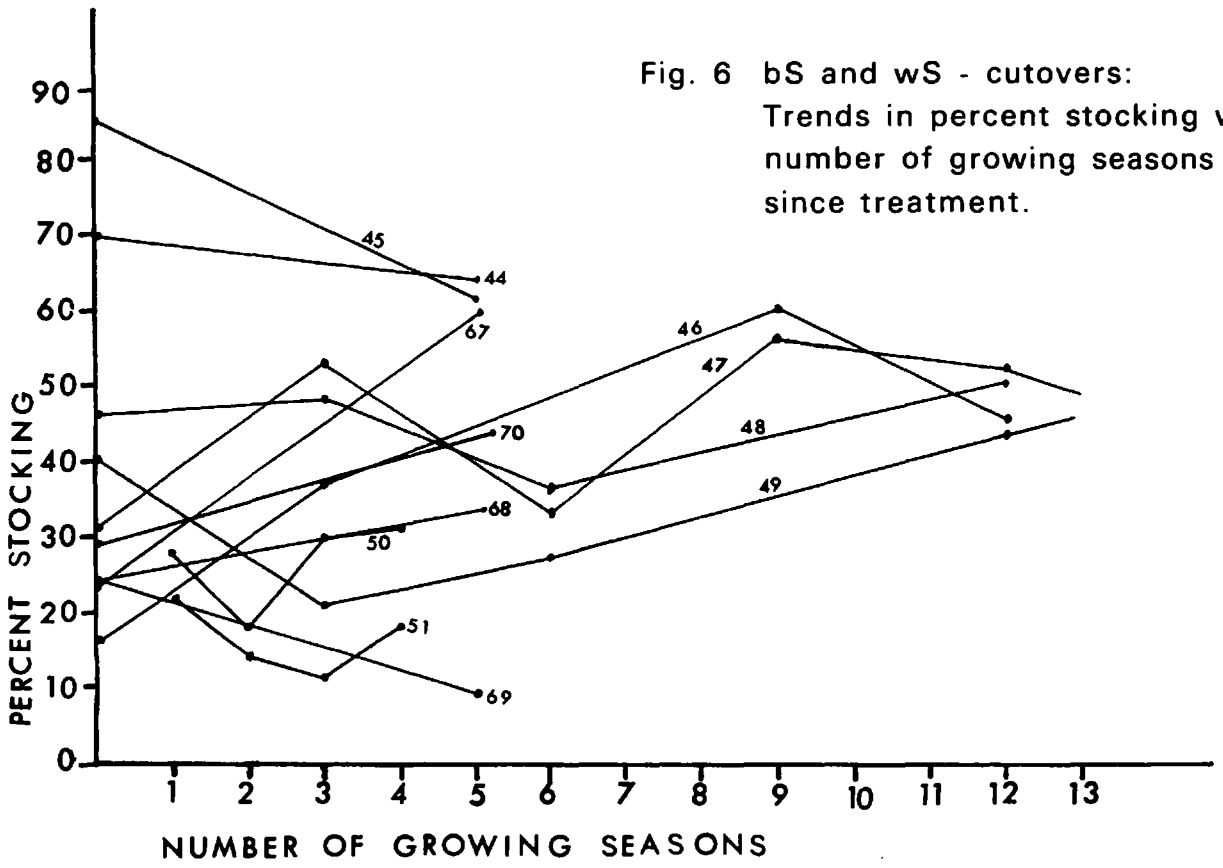



Fig. 6 bS and wS - cutovers:
Trends in percent stocking with number of growing seasons since treatment.

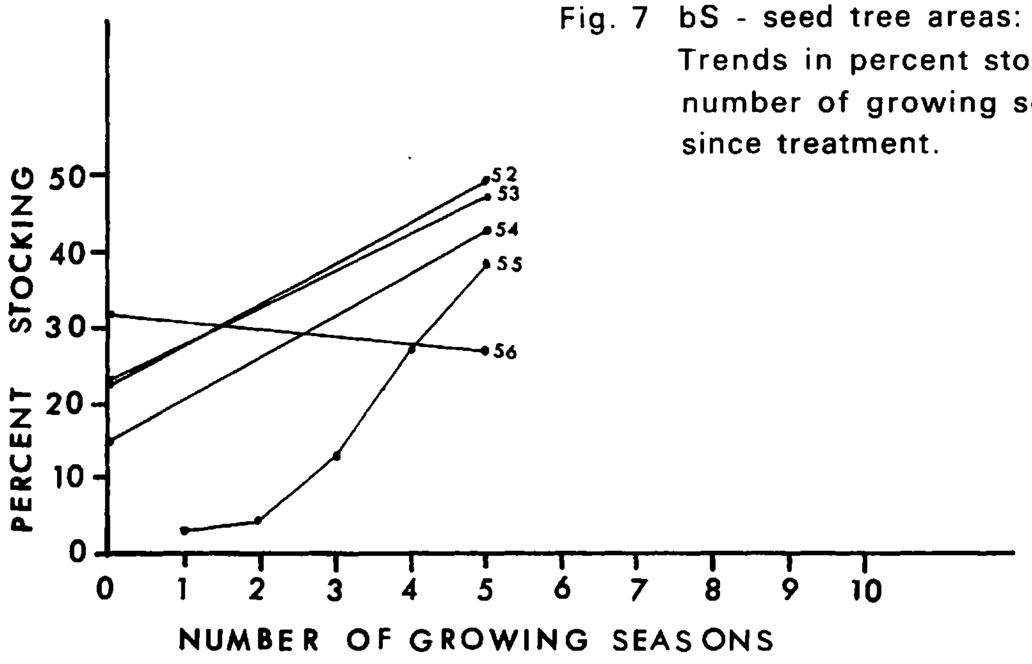



Fig. 7 bS - seed tree areas:
Trends in percent stocking with number of growing seasons since treatment.

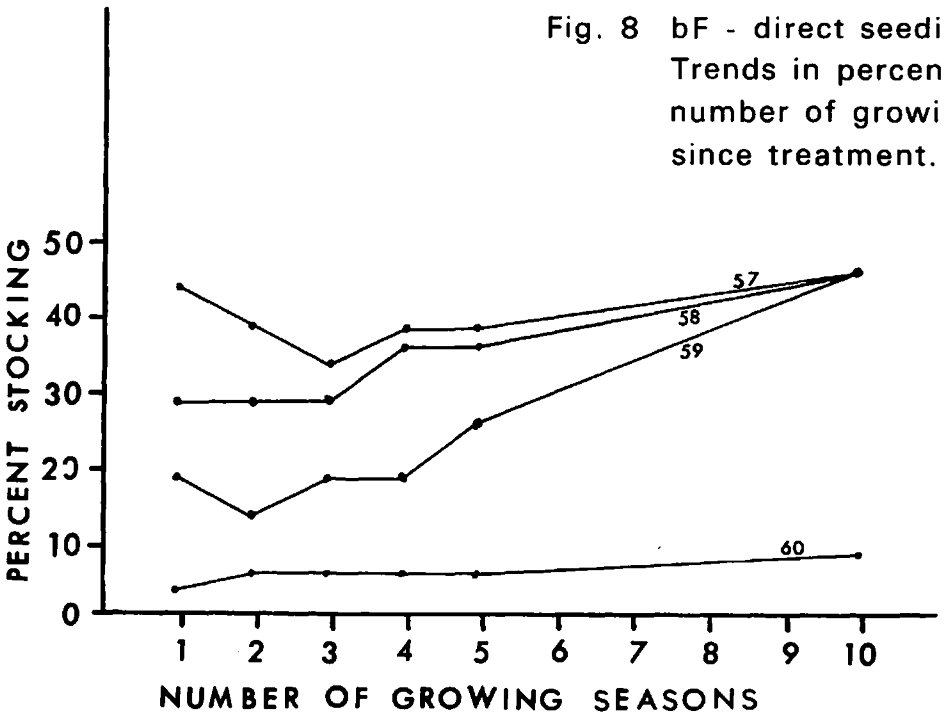



Fig. 8 bF - direct seeding:
Trends in percent stocking with number of growing seasons since treatment.

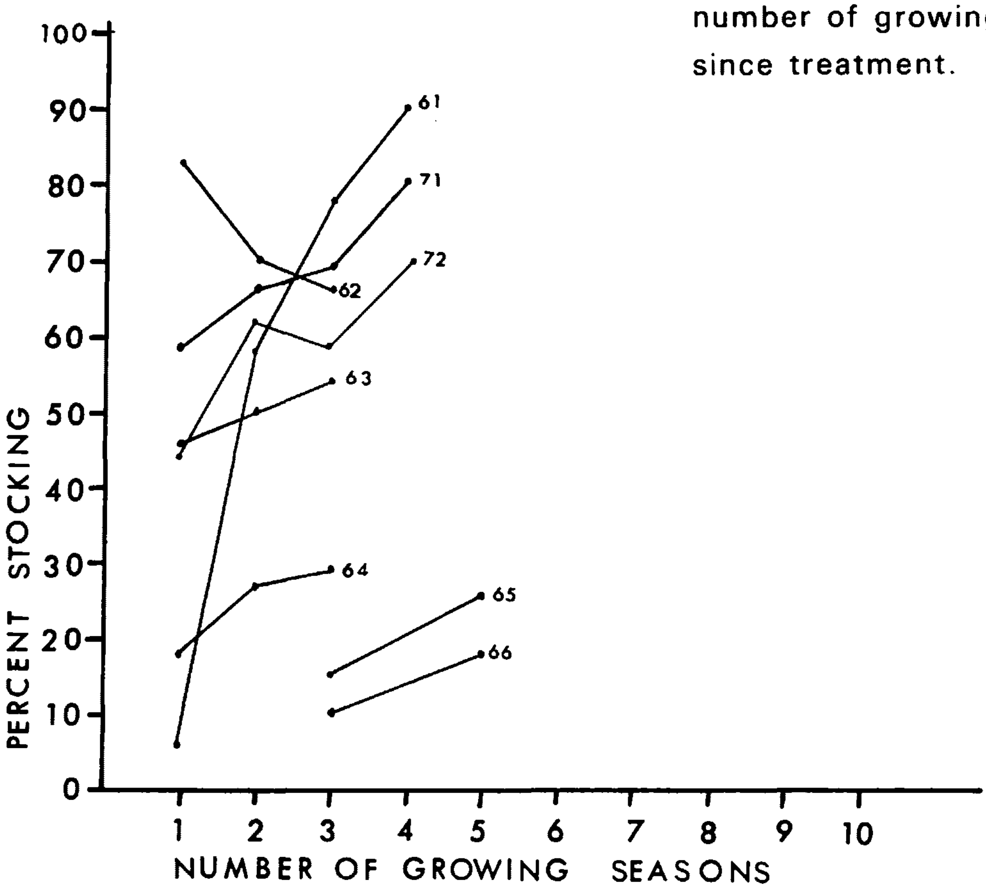



Fig. 9 bS - direct seeding:
Trends in percent stocking with number of growing seasons since treatment.

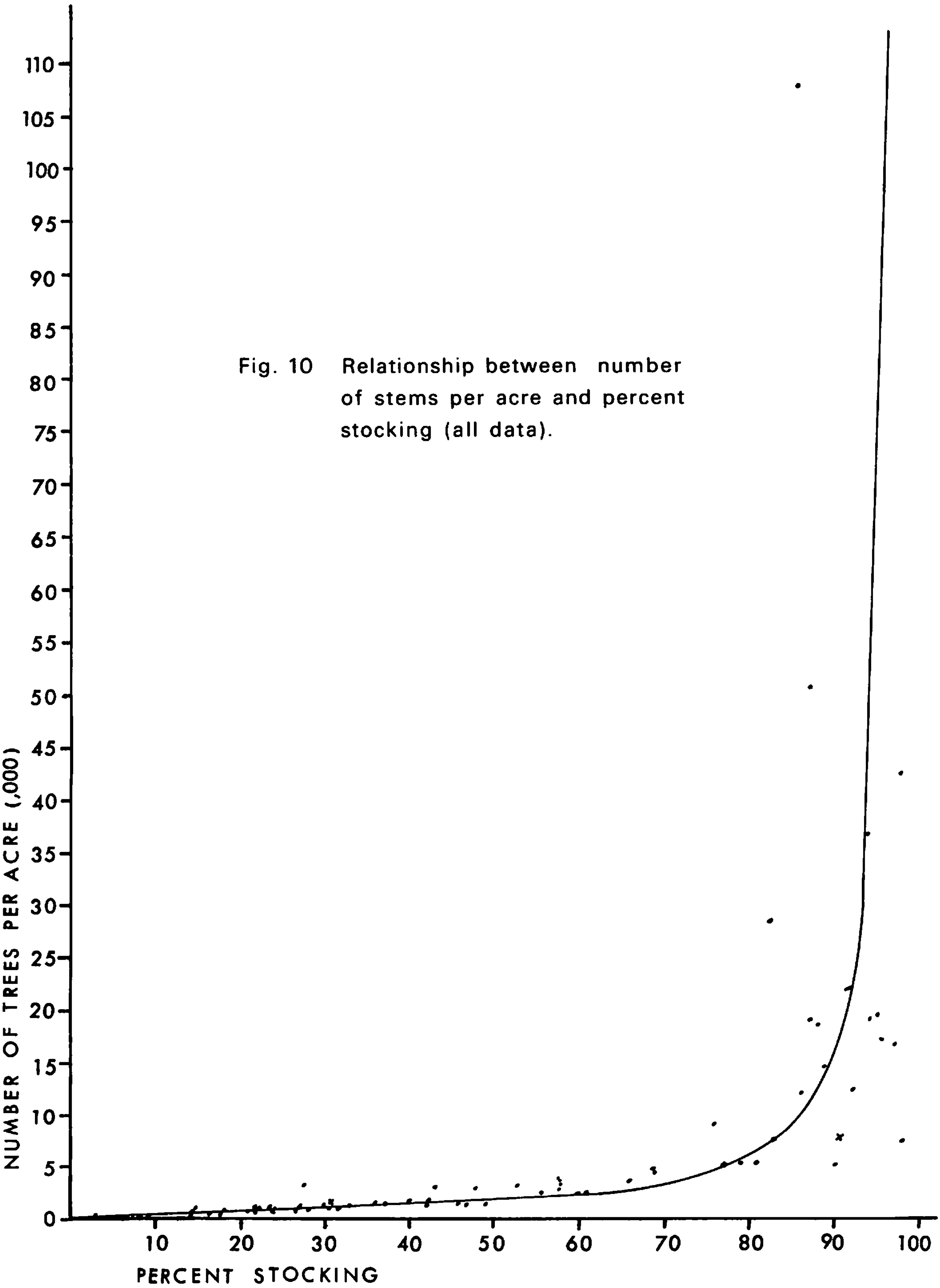



Fig. 10 Relationship between number of stems per acre and percent stocking (all data).

Distribution of the stems and the intensity of sampling are very important, however, and 1000 stems per acre may, for example, be associated with stocking values between 20% (usually regarded as indicating 'unsuccessful' regeneration) and 50% (usually regarded as satisfactory).

The most rapid and erratic changes in percent stocking occur during the first five years following treatment. Subsequent changes are less rapid and more consistent. Five-year old crops do not represent an entirely static conditions, however, (see, for example, trend lines 57-59, Figure 8), and the success of any site or seeding treatment cannot be assessed at this stage of development with any degree of certainty without reference to current seedbed and ground vegetation conditions and to the further availability of seed.

## Height Growth

Height growth shows the clearest and most consistent course of development of all the factors that have been examined. Results from five projects for the first ten years of development are listed in Table 3 (Appendix 1). Twenty-year figures for cutovers in central Newfoundland are included in Table 4.

Trends are shown graphically by treatment and species in Figures 11-15. Data represent the average height of the tallest seedling of the species concerned per milacre quadrat; those few cases where height appears to decrease can therefore be explained by additional germination in previously unstocked quadrats or by the death of some of the taller stems.

Height growth is slow during the first five-year period, with seedlings averaging between one and five inches per year. Where advance growth makes up a large proportion of the young crop there is usually an early height advantage which is maintained for at least the first five years. Height development becomes increasingly rapid between 5 and 15 or 20 years. If most of the trees of a given species are no longer represented in the dominant height class, however, height increment, after showing an early tendency to increase, begins to decrease about 10 years after initial treatment. This type of situation is shown by most of the height growth curves for black and white spruce on balsam fir cutovers, where the spruce is only a minor component of the stand. For example, average annual height increments for spruce in project NF-47 (Table 4) reach 0.47 and 0.62 feet at approximately 10 years in forest types 1 and 4, respectively. Corresponding figures for 10 to 20 year-old crops are 0.06 and 0.28 feet.

Where height growth has been relatively rapid, a height of 4½ feet has been reached in 8 to 12 years. For slower growing crops, present indications are that 15 or even 20 years may be needed to reach that level. These figures are conservative when considered in relation to the average height growth of the 4 tallest trees per 1/10 acre or the 40 tallest trees per acre, which are commonly used indices of height growth for older crops. On this latter basis, between 5 and 15 years to reach 4½ feet would seem the most reasonable estimate for productive sites.

Fig. 11 bF - cutovers:
Trends in height growth with number of growing seasons since treatment.

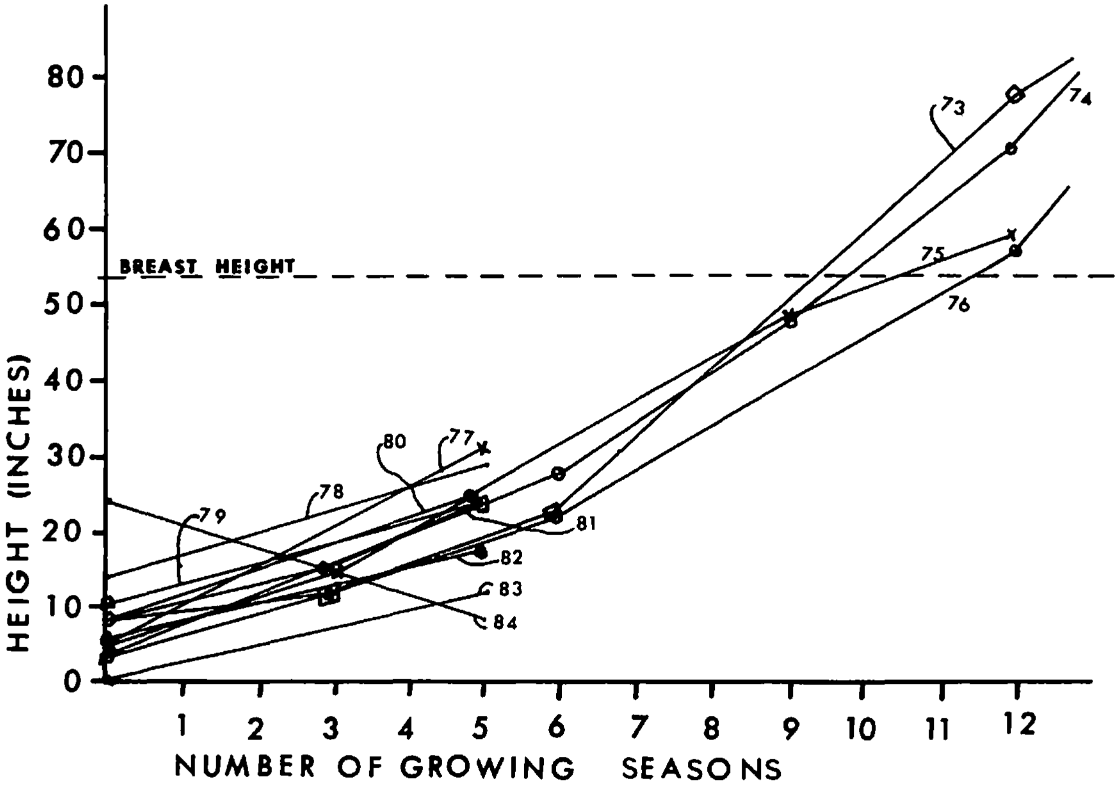


Fig. 12 bS and wS - cutovers: Trends in height growth with number of growing seasons since treatment.

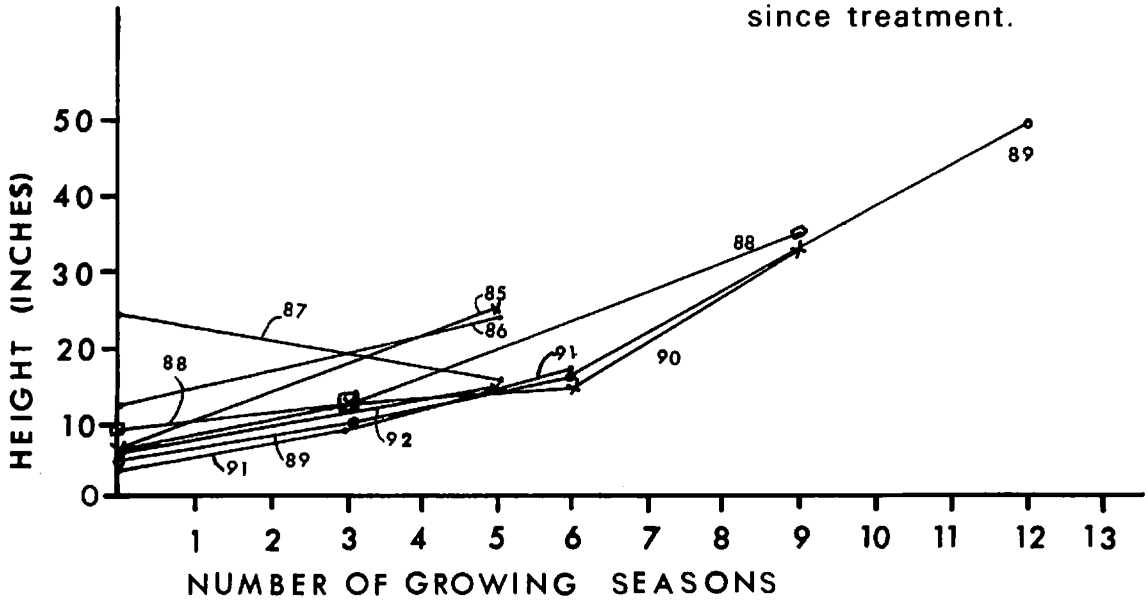
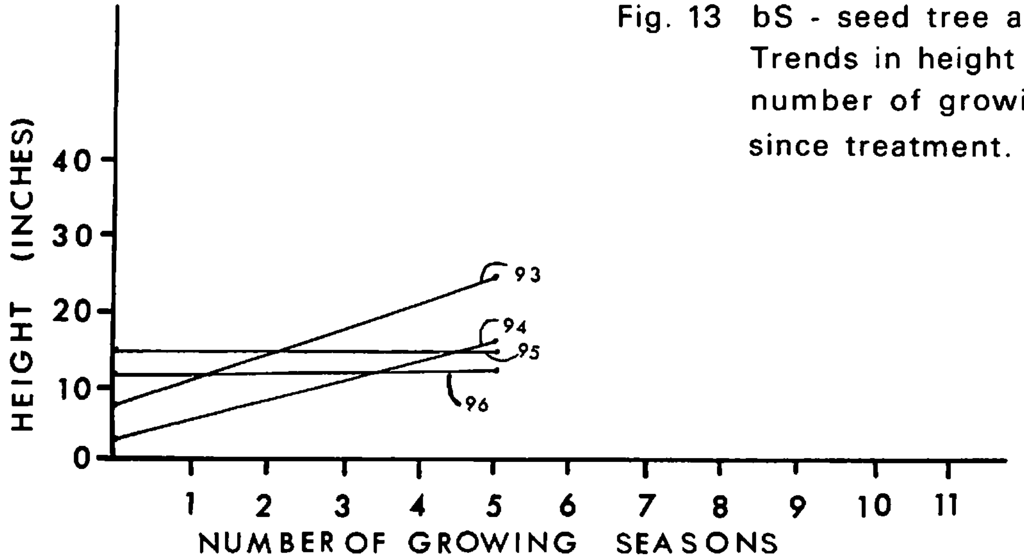



Fig. 13 bS - seed tree areas: Trends in height growth with number of growing seasons since treatment.



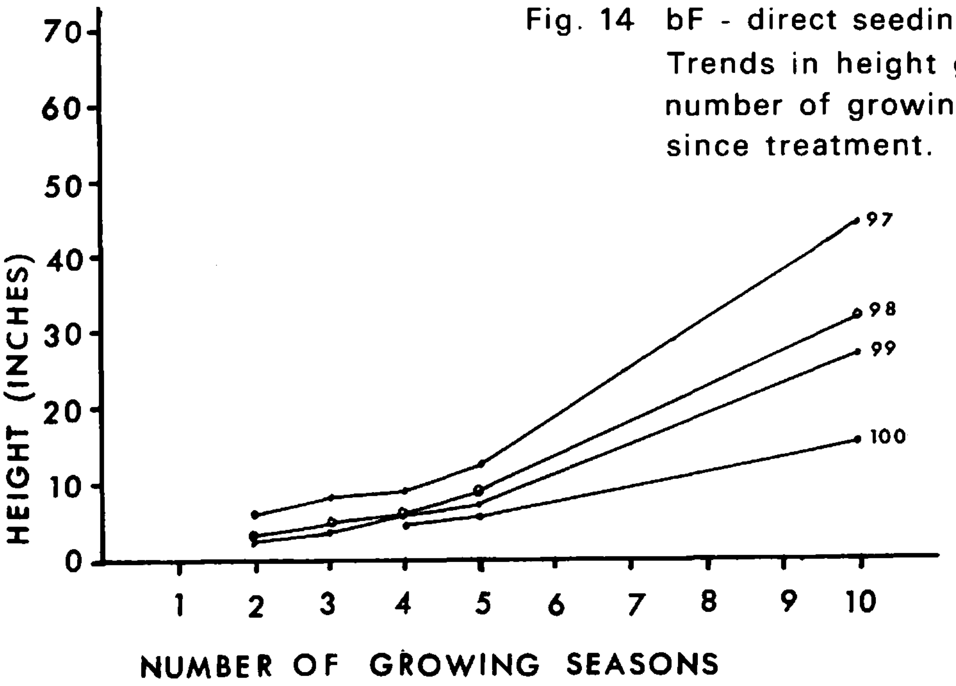



Fig. 14 bF - direct seeding: Trends in height growth with number of growing seasons since treatment.

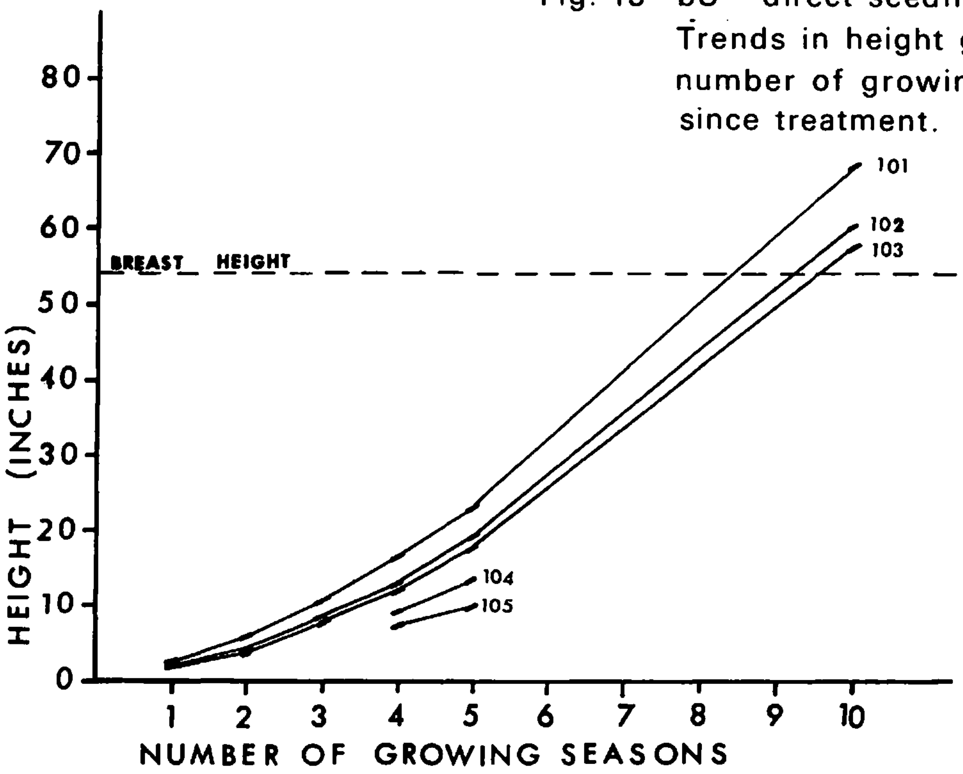



Fig. 15 bS - direct seeding: Trends in height growth with number of growing seasons since treatment.

Site potential will have an obvious effect on growth and this can be considered to account for much of the variation in height growth on the balsam fir cutovers where different site conditions have been sampled. However, site preparation and seeding treatment, within one area with the same site potential, also appear to have a very significant effect on later growth. Early differences in rate of establishment and growth which are, presumably, controlled by the method of seeding, the nature of the seedbed and the degree of vegetative competition, seem to result in the establishment of a pattern of growth which is maintained in later development (e.g. see Figures 14 and 15). Thus a series of harmonic, and ever-widening curves are produced.

Unfortunately, data are insufficient to determine whether these divergent height growth patterns are maintained above 4½ feet (the usual reference point for age determination). If they are maintained, then the use of age at breast height when sampling mature crops will not, as is commonly assumed, produce data relatively unaffected by early growth differences. There may also be important silvicultural implications. Seedbed conditions could be of vital significance in establishing a pattern of rapid early growth which would then be maintained. On the same basis, some sites which are presently regarded as less fertile than others may only exhibit lower productivity as a result of initial unsuitability for seedling establishment. Even if true site potential is ultimately expressed in crops on such "less fertile" areas, the slower early development may be of major importance in the harvesting of pulpwood stands on relatively short rotations.

Similar circumstances could have an important bearing on the expression of dominance within a crop, as has been suggested by Ellis (1960). Sites with varied seedbed conditions may favour the early development of individual stems which then become dominant trees. Where seedbed conditions are uniform and there is a good seed supply, all seedlings are likely to develop at a uniform rate, with little opportunity for the early expression of dominance, possibly resulting in a dense, stagnated stand.

Other Parameters

Most studies have been concerned only with the three growth parameters already discussed. However, data are available for diameter and basal area of the 18-22 year old stands from project NF-47, for diameters at 10 years of age from project NF-45, and for mortality at yearly intervals up to 5 years of age from project NF-23.

In 18 to 22 year-old stands on balsam fir cutovers in central Newfoundland, there were between 725 and 2028 softwood stems per acre with a diameter of 0.6 inches or greater, within stands containing totals of between 6,000 and 11,000 stems per acre. Average diameters (stems 0.6 inches diameter or greater) ranged from 1.5 to 1.8 inches, and total basal areas were between 13.6 and 33.0 square feet per acre. In the black spruce plots at Cormack (Project NF-45) the average diameters at ten years of age of the tallest trees per quadrat ranged from 0.51 to 0.65 inches, with a mean of 0.58 inches. More rapid diameter growth was associated with a faster rate of height growth.

Seedling mortality in the southwest Gander strip cutting experiment (Project NF-23) equalled 5.6%, 5.8%, 2.0% and 3.8% of the total number of stems in the second to fifth years after treatment, respectively. Despite this there was a steady increase in percent stocking and number of stems per acre during the five-year observation period.

## CONCLUSIONS

Data on early stand development from a number of studies have been brought together in this report. Parameters measured and methods of sampling varied between projects, but sufficient similarities exist to permit a number of trends to be detected.

Conclusions are as follows:-

(1) Where large numbers of seedlings or advance growth are present following treatment, a very rapid reduction in density occurs during the first three to five years of stand development, the rate of decrease being roughly proportional to the initial density. Later decreases are slower, number of stems per acre at 20 years reaching about 5,000 to 10,000 on balsam fir cutovers.

(2) Where initial density is below 5,000 to 10,000 stems per acre, the number of seedlings commonly increases during the first five years. Obviously the seedbeds must remain in a receptive condition and vegetative competition not be severe to permit this to happen.

(3) Percent stocking figures reflect essentially the same trends as number of stems per acre although in a much less exact form. High stocking values are usually maintained up to about 20 years of age (while number of stems per acre is decreasing), while low values show a general tendency to increase, at least during the first ten years of development.

(4) Despite the above trends, early development is often erratic, both in terms of number of stems per acre and percent stocking. This is particularly apparent at lower stocking levels where the young softwood trees do not form a dominant part of the ground vegetation layer, or where one softwood species is dominated by another.

(5) A number of regeneration studies have regarded values for percent stocking and number of trees per acre obtained five years after clearcutting or seeding as being relatively stable figures on which to base an assessment of the success of a given treatment. While the most rapid change has already taken place by this time, significant changes continue to take place in many experiments up to at least ten years after treatment. Firm conclusions regarding regeneration success should not, therefore, be made at less than five years after treatment, at least until more complete data on

early stand development are available, owing to the rapid changes that are likely to be taking place. At five years or later conclusions should be made with caution and with reference to likely future trends as indicated by seedbed and ground vegetation conditions and further availability of seed.

(6) Height growth, based on the average height of the tallest seedling per milacre quadrat, usually shows a regular pattern of development and a progressively more rapid rate of growth up to 15 or 20 years of age. The use of a milacre quadrat basis can sometimes result in anomalies, however, when height growth appears to decrease owing to the germination of seedlings in quadrats which were previously unstocked.

(7) No direct conversion of the height readings used in this report into readings of height based on the four tallest areas per 1/10 acre is possible. The latter system will, however, give higher readings, at least after the first five years. From the data contained in this report it is estimated that between 5 and 15 years will be required for young stands of the merchantable forest types to reach breast height on the basis of the four tallest trees per 1/10 acre.

(8) Initial site or seeding treatment appears to have had a marked effect on subsequent height development. Small early differences in growth rate, which can be attributed directly to the treatment concerned, appear to establish a definite pattern of more or less rapid growth which is followed for at least 10 years. Even where no differences in site preparation are involved, early growth differences are maintained, resulting in the production of a series of harmonic, and ever-widening, curves. Data are insufficient to show whether the use of age at breast height would eliminate these effects although present indications are that this is unlikely. Diameter growth appears to be increased concurrently with height growth.

(9) If maintained over a sufficient period, these divergent growth patterns could be of major significance to silvicultural practice. Under natural conditions the expression of individual tree dominance may be due to microsite variation comparable to the treatment variations discussed above. Very uniform sites might be equally favourable to all seedlings that germinate and thus be predisposed to the development of dense, stagnated stands. Moreover, apparent fertility differences between certain sites may arise partly as a result of seedbed differences establishing a pattern of more or less rapid early growth. With present trends towards shorter rotations, differences of this kind may prove to be of considerable economic significance to forest management.

(10) Further investigations of the trends discussed in this report are essential. While the first five years after cutting or seeding

have been relatively well covered, the later development up to the attainment of merchantable size has received very little attention. Knowledge of stand growth patterns during this latter period is essential to a full explanation of the development trends, several of which are potentially of major significance to forest management.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Dickson, W.A. 1955. Experimental seeding - Cormack Burn. Project NF-10. Unpublished report. Can. Dept. North. Aff. Nat. Res., Forestry Br., Nfld. District Office. 10 pp.

Dickson, W.A. 1957. Progress report, 1956 examination of Chause Brook plots. Experimental seeding, balsam fir, Project NF-18. Unpublished report. Can. Dept. North. Aff. Nat. Res., Forestry Branch, Nfld. District Office. 7 pp.

Ellis, R.C. 1960. An investigation of the length of the regeneration period and of the yield potential of pulpwood cutovers in Newfoundland. Project NF-47. Unpublished report. Can. Dept. North. Aff. Nat. Res., Forestry Branch, Nfld. Region. Books 1 and 2. 96 pp. + Appendices.

van Nostrand, R.S. 1961. Progress Report. Southwest Gander black spruce seedbed study. Project NF-23. Unpublished report. Can. Dept. Forestry, For. Res. Br., Nfld. Region. 11 pp.

van Nostrand, R.S. 1962. Strip cutting in black spruce fire type stands to increase reproduction. Project NF-23. Can. Dept. Forestry, For. Res. Br., Mimeo, Nfld. 62-8. 18 pp.

van Nostrand, R.S. 1964a. Progress Report. Development of black spruce on plots artificially seeded at Cormack, Newfoundland. Project NF-45. Can. Dept. Forestry, For. Res. Br., Mimeo 64-N-13. 12 pp.

van Nostrand, R.S. 1964b. Results of experimental seeding of balsam fir on a recent burn. Can. Dept. Forestry, For. Res. Br., Project NF-18. Mimeo 64-N-9. 9 pp.

van Nostrand, R.S. 1965. Results of experimental seeding of balsam fir on a recent burn. Can. Dept. Forestry, For. Res. Br., Publication No. 1103. 11 pp.

van Nostrand, R.S. and D.E. Nickerson. 1965. Some observations on stand development following diameter limit cutting of virgin fir spruce stands in western Newfoundland. Unpublished report. Can. Dept. Forestry, For. Res. Br., Nfld. Region. 16 pp.

Robinson, A.J. 1969. Effect on future regeneration of leaving spruce seed trees. Information report. Can. Dept. Fisheries & Forestry, Canadian Forestry Service, Nfld. Region (in preparation).

## APPENDIX I

### Table 1

**Trends in number of stems per acre during first ten years of stand development**

| Project | Treatment | Sp. | Code No. on Figures | No. of stems per acre | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. of growing seasons since treatment | | | | | | |
| | | | | 0 (advance growth) | 1 | 2 | 3 | 4 | 5 | 10 |
| NF-23 | Strip cutting | bS | 21 | - | 119 | 208 | 491 | 1,564 | 2,088 | - |
| | " " | all sftwds | | - | 130 | 223 | 539 | 1,699 | 2,253 | - |
| NF-47 | Cutover: forest type 1 (mixed wood on lower slopes) | bF | 2 | 108,000 | - | - | 36,500 | - | 19,280* | - |
| | " " | bS & wS | 11 | 1,370 | - | - | 2,830 | - | 1,260* | - |
| | Cutover: forest type 2 (mixed wood on lower middle slopes) | bF | 4 | 50,500 | — | - | 18,500 | - | - | 12,400** |
| | " " | bS & wS | 13 | 500 | - | - | 1,030 | - | - | 2,280** |
| | Cutover: forest type 3 (bF forest on middle slopes) | bF | 1 | 152,800 | - | - | 42,200 | - | 19,550* | 16,700** |
| | " " | bS & wS | 20 | 1,500 | - | - | 3,120 | - | 935* | 2,300** |
| | Cutover: forest type 4 (bF forest on upper slopes) | bF | 3 | 186,500 | - | - | 22,050 | - | 12,000* | - |
| | " " | bS & wS | 15 | 1,500 | - | - | 640 | - | 1,060* | - |

(Cont'd 23)

Table 1. (Cont'd)

| Project | Treatment | Sp. | Code No. on Figures | No. of stems per acre | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. of growing seasons since treatment | | | | | | |
| | | | | 0 | 1 | 2 | 3 | 4 | 5 | 10 |
| NF-84 | Aerial seeding | bS | 27 | - | 60 | 2,690 | 4,967 | 5,000 | - | - |
| NF-98 | Scarified seeded | bS | 26 | - | 3,700 | 3,600 | 4,400 | 5,2000 | - | - |
| | Scarified unseeded | bS | 17 | - | 1,100 | 300 | 400 | 700 | - | - |
| | Unscarified seeded | bS | 28 | - | 3,000 | 2,100 | 3,400 | 4,500 | - | - |
| | Unscarified unseeded | bS | 19 | - | 3,280 | 600 | 1,100 | 1,500 | - | - |
| NF-72 | Area 1 - clear cut | bS | 12 | 982 | - | - | - | - | 3,300 | - |
| | " " " | bF | | 0 | - | - | - | - | 136 | - |
| | Area 1 - seed trees | bS | 22 | 694 | - | - | - | - | 1,553 | - |
| | " " " | bF | | 294 | - | - | - | - | 294 | - |
| | Area 2 - clear cut | bS | 16 | 470 | - | - | - | - | 661 | - |
| | " " " | bF | 6 | 18,848 | - | - | - | - | 14,478 | - |
| | Area 2 - seed trees | bS | 23 | 678 | - | - | - | - | 1,064 | - |
| | " " " | bF | 5 | 28,522 | - | - | - | - | 16,886 | - |
| | Area 3 - clear cut | bS | 18 | 467 | - | - | - | - | 124 | - |
| | " " " | bF | 8 | 10,333 | - | - | - | - | 7,667 | - |
| | Area 3 - seed trees | bS | 25 | 562 | - | - | - | - | 486 | - |
| | " | bF | 7 | 17,571 | - | - | - | - | 9,048 | |
| | Area 4 - clear cut | bS | 14 | 519 | - | - | - | - | 1,205 | - |
| | " " " | bF | 10 | 5,286 | - | - | - | - | 7,619 | - |
| | Area 4 - seed trees | bS | 24 | 400 | - | - | - | - | 1,045 | - |
| | " - " " | bF | 9 | 7,375 | - | - | - | - | 7,325 | - |

*......... 6 growing seasons after treatment

**......... 9 " " " "

## Table 2

Trends in percent stocking figures during first ten

years of stand development

| Project | Treatment | Sp. | Code No. on Figures | % Stocked Quadrats | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. of growing seasons since treatment | | | | | | |
| | | | | 0 (advance growth) | 1 | 2 | 3 | 4 | 5 | 10 |
| NF-10/ NF-45 | Seed broadcast on snow | bS | 62 | - | 82.5 | 70.0 | 66.0 | - | - | - |
| | Seed broadcast on ground | bS | 64 | - | 17.5 | 27.0 | 29.0 | - | - | - |
| | Seedspots | bS | 63 | - | 45.5 | 49.8 | 53.8 | - | - | - |
| NF-18 | Broadcast on turf (high intensity) | bF | 58 | - | 27.5 | 27.5 | 27.5 | 35.0 | 35.0 | 45.0 |
| | Broadcast on turf (medium intensity) | bF | 59 | - | 17.5 | 12.5 | 17.5 | 17.5 | 25.0 | 45.0 |
| | Broadcast on turf (low intensity) | bF | 60 | - | 2.5 | 5.0 | 5.0 | 5.0 | 5.0 | 7.5 |
| | Seedspots | bF | 57 | - | 42.5 | 37.4 | 32.5 | 37.5 | 37.5 | 45.0 |
| | All treatments | bS | - | - | - | - | - | - | - | 21.5 |
| NF-23 | Strip cutting | bS | 55 | - | 3.0 | 4.5 | 13.0 | 27.0 | 38.5 | - |
| | " " | All sftwds | | - | 3.0 | 4.5 | 16.0 | 30.0 | 41.0 | - |

(Cont'd 25)

Table 2. (Cont'd)

| Project | Treatment | Sp. | Code No. On Figures | % Stocked Quadrats | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. of growing seasons since treatment | | | | | | |
| | | | | 0 | 1 | 2 | 3 | 4 | 5 | 10 |
| NF-41 | Diameter limit Cutting-bF forest | bF | 39 | 92.9 | - | - | - | - | 67.6 | - |
| | " | All sftwds | | 94.9 | - | - | - | - | 68.6 | - |
| | Diameter limit Cutting-bF/bS forest | bF | 40 | 80.0 | - | - | - | - | 60.0 | - |
| | " | bS | 44 | 69.8 | - | - | - | - | 63.9 | - |
| | " | All sftwds | | 97.6 | - | - | - | - | 89.0 | - |
| | Diameter limit Cutting-bS forest | bF | 41 | 51.1 | - | - | - | - | 42.2 | - |
| | " | bS | 45 | 84.5 | - | - | - | - | 61.1 | - |
| | " | All sftwds | | 100.0 | - | - | - | - | 88.9 | - |
| NF-47 | Cutover-forest type 1 (mixed wood on lower slopes) | bF | 30 | 86.0 | - | - | 94.0 | - | 94.0* | - |
| | " " | bS & wS | 48 | 46.0 | - | - | 48.0 | - | 36.0* | - |
| | Cutover-forest type 2 (mixed wood on lower middle slopes) | bF | 32 | 87.0 | - | - | 88.0 | - | - | 92.0** |
| | " " | bS & wS | 46 | 16.0 | - | - | 37.0 | - | - | 60.0** |
| | Cutover-forest type 3 (bF forest on middle slopes) | bF | 29 | 99.0 | - | - | 99.0 | - | 95.0* | 97.0** |
| | " " | bS & wS | 47 | 31.0 | - | - | 53.0 | - | 33.0* | 56.0** |

(Cont'd 26)

Table 2. (Cont'd)

| Project | Treatment | Sp. | Code No. on Figures | % Stocked Quadrats — No. of growing seasons since treatment | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 1 | 2 | 3 | 4 | 5 | 10 |
| | Cutover-forest type 4 (bF forest on upper slopes) | bF | 31 | 85.0 | - | - | 92.0 | - | 86.0* | - |
| | " " | bS & wS | 49 | 40.0 | - | - | 21.0 | - | 27.0* | - |
| NF-84 | Aerial seeding | bS | 61 | - | 6.0 | 58.0 | 77.0 | 90.0 | - | - |
| NF-86 | Seedspotting - Fishel's Brook | bS | 65 | - | - | - | 15.0 | - | 26.0 | - |
| | Seedspotting - Norris Arm | bS | 66 | - | - | - | 10.0 | - | 13.0 | - |
| NF-98 | Scarified - seeded | bS | 71 | - | 58.0 | 66.0 | 69.0 | 79.0 | - | - |
| | Scarified - unseeded | bS | 51 | - | 22.0 | 14.0 | 11.0 | 18.0 | - | - |
| | Unscarified - seeded | bS | 72 | - | 43.0 | 61.0 | 58.0 | 69.0 | - | - |
| | Unscarified - unseeded | bS | 50 | - | 28.0 | 18.0 | 30.0 | 31.0 | - | - |
| NF-72 | Area 1 - clear cut | bS | 67 | 23.6 | - | - | - | - | 58.2 | - |
| | " " " | bF | 43 | 0.0 | - | - | - | - | 9.1 | - |
| | Area 1 - seed trees | bS | 54 | 14.7 | - | - | - | - | 42.4 | - |
| | " " " | bF | 42 | 2.9 | - | - | - | - | 17.6 | - |
| | Area 2 - clear cut | bS | 68 | 23.9 | - | - | - | - | 30.4 | - |
| | " " " | bF | 35 | 87.0 | - | - | - | - | 89.1 | - |
| | Area 2 - seed trees | bS | 53 | 22.2 | - | - | - | - | 46.8 | - |
| | " " " | bF | 34 | 82.5 | - | - | - | - | 95.5 | - |

(Cont'd 27)

Table 2. (Cont'd)

| Project | Treatment | Sp. | Code No. on Figures | % Stocked Quadrats | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. of growing seasons since treatment | | | | | | |
| | | | | 0 | 1 | 2 | 3 | 4 | 5 | 10 |
| | Area 3 - clear cut | bS | 69 | 23.8 | - | - | - | - | 8.6 | - |
| | " " " | bF | 37 | 76.2 | - | - | - | - | 90.5 | - |
| | Area 3 - seed trees | bS | 56 | 31.4 | - | - | - | - | 26.7 | - |
| | " " " | bF | 38 | 61.9 | - | - | - | - | 76.0 | - |
| | Area 4 - clear cut | bS | 70 | 28.6 | - | - | - | - | 41.0 | - |
| | " " " | bF | 36 | 81.0 | - | - | - | - | 90.5 | - |
| | Area 4 - seed trees | bS | 52 | 22.0 | - | - | - | - | 49.0 | - |
| | " " " | bF | 33 | 82.5 | - | - | - | - | 97.5 | - |

*.......... 6 growing seasons after treatment
**.......... 9 " " " "

<u>Table 3</u>

Trends in height growth during first ten years

of stand development

| Project | Treatment | Sp. | Code No. on Figures | Average height (ins.) of tallest seedling per milacre quadrat | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. of growing seasons since treatment | | | | | | |
| | | | | 0 (advance growth) | 1 | 2 | 3 | 4 | 5 | 10 |
| NF-10/ NF-45 | Seed broadcast on snow | bS | 102 | - | 1.6 | 4.2 | 8.4 | 13.2 | 19.2 | 60.4 |
| | Seed broadcast on ground | bS | 103 | - | 1.6 | 3.8 | 7.7 | 12.2 | 17.8 | 58.7 |
| | Seedspots | bS | 101 | - | 2.4 | 5.8 | 10.8 | 16.8 | 23.2 | 68.3 |
| NF-18 | Broadcast on turf (high intensity) | bF | 98 | - | - | 3.2 | 4.9 | 5.7 | 8.8 | 31.1 |
| | Broadcast on turf (medium intensity) | bF | 99 | - | - | 2.3 | 3.6 | 5.9 | 7.0 | 26.3 |
| | Broadcast on turf (low intensity) | bF | 100 | - | - | - | - | 4.5 | 5.5 | 15.0 |
| | Seedspots | bF | 97 | - | - | 5.4 | 7.9 | 8.8 | 12.0 | 43.8 |
| | All treatments | bS | | - | - | - | - | - | - | 23.0 |
| NF-47 | Cutover-forest type 1 (mixed wood on lower slopes) | bF | 76 | 8.4 | - | - | 12.0 | - | 21.6* | - |
| | " " | bS & wS | 89 | 4.8 | - | - | 9.6 | - | 15.6* | - |
| | Cutover - forest type 2 (mixed wood on lower-middle slopes) | bF | 75 | 4.8 | - | - | 14.4 | - | - | 48.0** |
| | " " | bS & wS | 88 | 8.4 | - | - | 12.0 | - | - | 34.8** |
| | Cutover-forest type 3 (bF forest on middle slopes) | bF | 74 | 8.4 | - | - | 15.6 | - | 27.6* | 46.8** |
| | " " | bS & wS | 90 | 6.0 | - | - | 12.0 | - | 14.4* | 32.4** |

(Cont'd 29)

Table 3. (Cont'd)

| Project | Treatment | Sp. | Code No. on Figures | Average height (ins.) of tallest seedling per milacre quadrat | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. of growing seasons since treatment | | | | | | |
| | | | | 0 | 1 | 2 | 3 | 4 | 5 | 10 |
| | Cutover-forest type 4 (bF forest on upper slopes) | bF | 73 | 3.6 | - | - | 12.0 | - | 22.8* | - |
| | " " | bS & wS | 91 | 3.6 | - | - | 8.4 | - | 16.8* | - |
| NF-86 | Seedspotting - Fishel's Brook | bS | 104 | - | - | - | - | 9.1 | 13.6 | - |
| | Seedspotting - Norris Arm | bS | 105 | - | - | - | - | 7.3 | 10.1 | - |
| NF-72 | Area 1 - clear cut | bS | 87 | 24.0 | - | - | - | - | 15.6 | - |
| | " " " | bF | 83 | 0.0 | - | - | - | - | 12.0 | - |
| | Area 1 - seed trees | bS | 96 | 10.8 | - | - | - | - | 12.0 | - |
| | " " " | bF | 84 | 24.0 | - | - | - | - | 8.4 | - |
| | Area 2 - clear cut | bS | 85 | 6.0 | - | - | - | - | 25.2 | - |
| | " " " | bF | 77 | 4.8 | - | - | - | - | 31.2 | - |
| | Area 2 - seed trees | bS | 93 | 7.2 | - | - | - | - | 24.0 | - |
| | " " " | bF | 81 | 3.6 | - | - | - | - | 24.0 | - |
| | Area 3 - clear cut | bS | 86 | 12.0 | - | - | - | - | 24.0 | - |
| | " " " | bF | 78 | 14.4 | - | - | - | - | 28.8 | - |
| | Area 3 - seed trees | bS | 95 | 14.4 | - | - | - | - | 14.4 | - |
| | " " " | bF | 80 | 8.4 | - | - | - | - | 25.2 | - |
| | Area 4 - clear cut | bS | 92 | 6.0 | - | - | - | - | 14.4 | - |
| | " " " | bF | 79 | 10.8 | - | - | - | - | 24.0 | - |
| | Area 4 - seed trees | bS | 94 | 2.4 | - | - | - | - | 15.6 | - |
| | " " " | bF | 82 | 6.0 | - | - | - | - | 18.0 | - |

*........ 6 growing seasons after treatment
**........ 9 " " "

## Table 4

Development of young stands up to 22 years of age
in central Newfoundland - Project NF-47 (from Ellis, 1960)

| Factor | Sp. | Forest type | Code No. on Figures | No. of growing seasons since treatment: Advance growth | 3 | 6 | 9 | 11-13 | 18-19 | 21-22 |
|---|---|---|---|---|---|---|---|---|---|---|
| % stocking | bF | 1 | 30 | 86 | 94 | 94 | — | 90 | - | 88 |
| | bS+wS | (mixed wood on lower | 48 | 46 | 48 | 36 | — | 50 | - | bS-6 wS-8 |
| | wB | slopes) | | 20 | 65 | 90 | | 55 | - | 32 |
| | bF | 2 | 32 | 87 | 88 | - | 92 | 86 | - | - |
| | bS+wS | (mixed wood on lower- | 46 | 16 | 37 | - | 60 | 45 | - | - |
| | wB | middle slopes) | | 10 | 61 | - | 54 | 46 | - | - |
| | bF | 3 | 29 | 99 | 99 | 95 | 97 | 91 | 88 | - |
| | bS+wS | (bF forest on middle | 47 | 31 | 53 | 33 | 56 | 52 | bS-28 wS-3 | - |
| | wB | slopes) | | 45 | 56 | 86 | 78 | 58 | 10 | - |
| | bF | 4 | 31 | 85 | 92 | 86 | - | 87 | 95 | 90 |
| | bS+wS | (bF forest on upper | 49 | 40 | 21 | 27 | - | 43 | bS-57 wS-3 | bS-16 wS-0 |
| | wB | slopes) | | 28 | 56 | 53 | - | 63 | 22 | 10 |
| Number of stems/acre | bF | 1 | 2 | 108,000 | 36,500 | 19,280 | - | 16,600 | - | 7,250 |
| | bS+wS | (mixed wood on lower | 11 | 1,370 | 2,830 | 1,260 | - | 2,580 | - | 244 |
| | wB | slopes) | | 5,130 | 4,750 | 5,450 | - | 4,420 | - | 940 |
| | bF | 2 | 4 | 50,500 | 18,500 | - | 12,400 | 7,080 | - | - |
| | bS+wS | (mixed wood on lower- | 13 | 500 | 1,030 | - | 2,280 | 2,080 | - | - |
| | wB | middle slopes) | | 190 | 4,970 | - | 3,920 | 3,390 | - | - |

( Cont'd 31)

Table 4. (Cont'd)

| Factor | Sp. | Forest type | Code No. on Figures | No. of growing seasons since treatment: Advance growth | 3 | 6 | 9 | 11-13 | 18-19 | 21-22 |
|---|---|---|---|---|---|---|---|---|---|---|
| | bF | 3 | 1 | 152,800 | 42,200 | 19,550 | 16,700 | 13,850 | 5,320 | - |
| | bS+wS | (bF forest on middle | 20 | 1,500 | 3,120 | 935 | 2,300 | 740 | 1,102 | - |
| | wB | slopes) | | 6,800 | 4,970 | 10,500 | 2,375 | 2,070 | 141 | - |
| | bF | 4 | 3 | 186,500 | 22,050 | 12,000 | - | 9,700 | 6,915 | 9,390 |
| | bS+wS | (bF forest on upper | 15 | 1,500 | 640 | 1,060 | - | 1,320 | 2,285 | 1,343 |
| | wB | slopes) | | 2,700 | 2,560 | 4,500 | - | 3,020 | 400 | 494 |
| Average height (feet) of tallest stem per quadrat | bF | 1 | 76 | 0.7 | 1.0 | 1.8 | - | 4.7 | - | 14.3 |
| | bS+wS | (mixed wood on lower | 89 | 0.4 | 0.8 | 1.3 | - | 4.1 | - | 4.7 |
| | wB | slopes) | | 0.9 | 1.2 | 1.8 | - | 2.1 | - | 1.8 |
| | bF | 2 | 75 | 0.4 | 1.2 | - | 4.0 | 4.9 | - | - |
| | bS+wS | (mixed wood on lower- | 88 | 0.7 | 1.0 | - | 2.9 | 4.2 | - | - |
| | wB | middle slopes) | | 0.5 | 1.1 | - | 2.4 | 2.1 | - | - |
| | bF | 3 | 74 | 0.7 | 1.3 | 2.3 | 3.9 | 5.9 | 12.2 | - |
| | bS+wS | (bF forest on | 90 | 0.5 | 1.0 | 1.2 | 2.7 | 5.0 | 6.2 | - |
| | wB | middle slopes) | | 0.5 | 1.2 | 2.1 | 2.5 | 2.5 | 1.3 | - |
| | bF | 4 | 73 | 0.3 | 1.0 | 1.9 | - | 6.4 | 10.0 | 12.2 |
| | bS+wS | (bF forest on | 91 | 0.3 | 0.7 | 1.4 | - | 5.1 | 7.0 | 7.8 |
| | wB | upper slopes | | 0.4 | 0.7 | 1.8 | - | 2.8 | 1.3 | 1.5 |